Mobile Gateway for Wireless Sensor Networks utilizing drones

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***Abstract*—Mobile Gateway for Wireless Sensor Networks utilizing drones**

The use of Wireless Sensor Networks is increasing and are beeing used in places were maintenance is dificult. Because of the power limitations, the nodes have a transmision range of only a few tens of meters which results in creating a multi-hop wireless sensor network architecture in order to send the data from any node to a gateway. But in some cases, creating this type of network might be to difficult or to expensive. Our design offers a truly mobile gateway using a SparrowDongle connected to a Parrot Drone. This setup allows us not only to collect data from a node, but also to debug a wireless sensor network. [4]

***Index Terms*—gateway, wireless sensor networks, drone**

I. Introduction

Wireless Sensor Networks are being used more and more in almost every field imaginable in order to collect and improve our life, fileds like home automation, agriculture, military, space exploration etc. In order to collect the data, gateway platforms [5], [2], [3] are required and most of them are stationary bulky devices or PCs connected to one of the wireless nodes that serve as a base-station. We aim to show in this paper that there exists a solution for a truly mobile gateway design that can be used either for collecting data or for debuging large wireless network infrastructures.

We have conected to an AR Parrot Drone 2.0 our SparrowDongle, a USB stick featuring two microcontrollers that can connect to 2.4GHz Zigbee nodes or to our own node design Sparrowv3.2. We will show an overview of the system architecture in Chapter II, the hardware and software implementation in Chapter III and results of using the gateway in Chapter IV.

II. System architecture

Te classic way of implementing a gateway is by using stationary devices or mobile devices like laptops or phones connected to at least one wireless node. The problem with this type of mobile devices is that you have to be in close proximity of the node in order to communicate with it. This might not be a problem if the nodes are easily accesible, but if a node is situated at a high altitude or over a clif, or even at an unknown location, using drones seems to be the best alternative.

Figure 1. SparrowDongle connected to AR Parrot Drone 2.0

Having this to say, our design has a number of features useful in everyday interaction with a wireless node outlined in II-A.

They can be launch from anyware, fly to any place a node might be placed and gather all the information collected by the nodes.

Additionally, a number of design features were included for ease-of-use in research and development, outlined in II-B

A. Ease of interaction

The drone automaticaly detects and initiates a comunication with a nearby node. It searches permanently for any signal emited by a node and sends an ack back to it when it receives any signal. After this first handshake is complet, the node has green light to transmit the information to the gateway installed on the drone. If a node has been detected, the pilot is informed of its presence and if the data transaction completed succesfuly so that he may continue in the search for another node.

B. Proximity function

The SparrowDongle can supply informations regarding the nearby nodes by reading the strength of the received signal. Using this information, the pilot can direct the drone closer to the nodes location, either for a faster transfer or to find its exact location.

Besides the signal strength offered by the SparrowDongle, the drone features an onboard camera with a resolution of

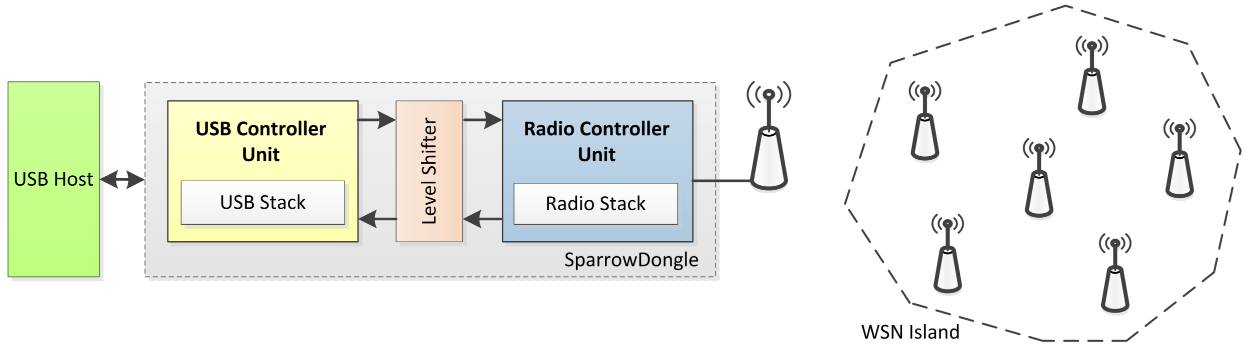

Figure 2. SparrowDongle stick architecture

1280x720 pixels streaming at 30 fps. This is very useful in determining the exact location of a wireless sensor node.

II-B.

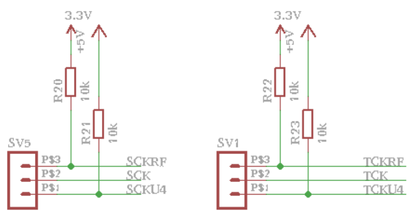

Figure 3. Header selection for programming clock signals

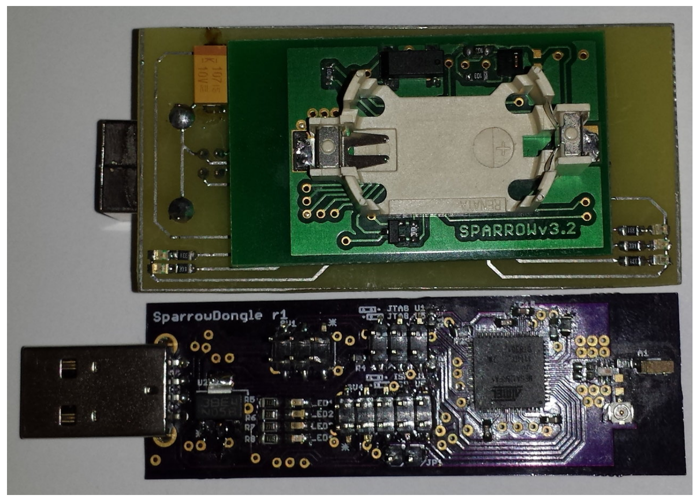

Figure 4. SparrowV3.2 and SparrowDongle

III. Implementation

A. Hardware Details

The hardware components used are the following:

- a SparrowDongle with two microcontrollers: The 8-bit ATMega128RFA1 which has an on-chip 2.4GHz wireless transceiver and the ATMega32U4, both from Atmel.
- a SparrowV3.2 with an ATMega128RFA1 microcontroller
- a AR Parrot Drone v2.0
- an laptop or mobile phone with android/ios for controlling the drone

Because of the addition of SparrowDongle, the drone's poliester hull has been carved a little in order to accomodate it.

B. Software Implementation

The SparrowDongle gateway dumps every data received on the serial. It is always in a listen for data state. When it receives the data, it sends back an ack to let the SparrowV3.2 know that it can begin sending the entire data to the mobile gateway.

The SparrowV3.2 node is sending periodicaly a small data packet to check if a gateway is available. When it receives the ack for the packet it starts sending the stored data to the gateway. The data sent can vary, from sensor readings, to debuging informations in order to check the state of the Wireless Sensor Network.

The data gathered by the gateway is saved into the AR Parrot Drone's internal memory. The data can be accesed at any time by any device connected to the drone's wireless network via ftp.

IV. Results

In this chapter we will cover the results obtained with this gateway platform and other possible applications.

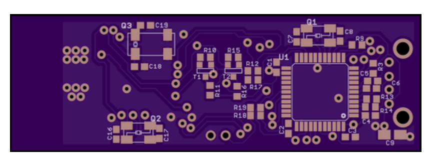

Figure 5. Bottom side of SparrowDongle PCB

A. Performance

Throughput testing was done with back-to-back packets sent at 250kbps over 2.4GHz with one sending node in acceptable

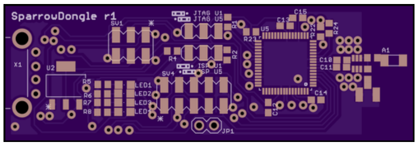

Figure 6. Top side of SparrowDongle PCB

range, with no losses. This is due to the double-buffering used in receiving packets from the wireless network. As soon as one packet ends, a signal is sent to the radio controller unit with a small delay of $9\mu S$. Even if a new packet starts in that small interval, receipt of the new packet goes unhindered as the first bytes of the old packet have already been transfered to a different memory location from which they will be sent to the USB controller unit via the serial connection.

B. Software configurations

A great advantage of using a dedicated USB Controller Unit for the gateway is that it can be programmed as one of several USB Communication Classes. The USB Controller Unit is not limited in implementing any of these classes since most of the computing power at its disposal is reserved for USB. SparrowDongle can appear as different USB devices:

- *Virtual Serial Port*: Communication with the wireless island around the gateway can be made via a serial link, incoming packets will appear on the receive end of this port and packets will be sent on the transmit end. In typical Unix fashion, our implementation sends packet in ASCII for ease of use and debugging. They are converted to binary form on the Radio Controller Unit of the gateway
- *Ethernet Emulation*: In this fashion, packets are received on the gateway and then encapsulated in an Ethernet packet sent over the USB link (Ethernet is emulated between the USB device and USB host)
- *Network card*: SparrowDongle behaves as a wireless network card, the operating system will register a network interface for the gateway and addresses assigned to this interface will change the gateway's address in the wireless medium (as opposed to changing the address for the emulated Ethernet)
- *Mass Storage*: SparrowDongle can offer a virtual filesystem interface for innovative data acquisition from the wireless sensor network. In accordance with the Unix philosophy of "everything is a file", the virtual filesystem offered by the USB stick could have a file for each wireless node where it stores recent data (as much as the gateway can store in its volatile memory, 1-2 records per node). The software implementation for this interface is under development.

C. Applications

The versatility of the SparrowDongle gateway platform allows it to be deployed in a wide range of applications, whether the gateway has to be connected to a PC or a small embedded device, whether it has to implement a virtual serial connection or to emulate an ethernet link.

For instance, these are the application in which SparrowDongle is currently deployed:

- Connected to a Windows PC, feeding wireless sensor data into a service framework for building control, in the FCINT project. [1]
- Connected to an Embedded Linux board, such as the small RaspberryPi, for plug-and-play monitoring of a wireless sensor island.
- Connected to a Parrot Drone [6], for remote monitoring using a mobile gateway.

V. Conclusion

The paper presented a versatile gateway platform for wireless sensor networks that is both capable of serving current application needs as well as offer the ability to interface sensor networks in a novel way (sensor data as files).

The platform is easy-to-use and to program due to clear separation of communication mediums on different controllers and benefits from the elimination of code duplication in the case of the radio controller unit.

Acknowledgment

The research presented in this paper was supported by the EU POS-CCE project "Ontology-based Service Composition Framework for Syndicating Building Intelligence: FCINT" No.181/18.06.2010

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